INTERNATIONAL RICE COMMISSION

NEWS LETTER

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SUMMARY REPORT OF THE 1955 MEETINGS OF THE TWO WORKING PARTIES OF THE INTERNATIONAL RICE COMMISSION

The Sixth Meeting of the Working Party on Rice Breeding and the Fifth Meeting of the Working Party on Fertilizers of the F.A.O. International Rice Commission, were convened by the Director-General of FAO and held concurrently from 5 to 11 December, 1955. The meetings were held in Penang through the kind invitation of the United Kingdom and the courtesy of the government of the Federation of Malaya. They were attended by 59 participants representing 15 governments and 2 special organizations. During the period excursion trips were arranged by the host government to see some of the main rice growing areas and test stations in the States of Kedah and Perak and Province Wellesley.

The following is a summary of recommendations and decisions of the meetings of these two Working Parties.

Working Party on Rice Breeding

This Working Party recommended that:

1) On the completion of the International Rice Hybridization Project, member countries should include reports on the progress made with the hybrids in their subsequent reports to the Working Party on their national rice breeding programs.

2) F.A.O. should organize a further training center for rice breeders by 1957 on similar lines to the previous ones, and that consideration should be given to

its location in a new area, such as Japan where facilities have been offered.

3) Copies of the lectures delivered at the previous and future training centers on rice breeding should be reproduced and made available to all member countries.

4) The attempt to determine a simple method of selection for lodging resistance for general application by coordinated experiments should be discontinued; but, in view of the growing interest in the subject, that countries should continue and expand the investigations currently in progress; and that countries which have already commenced, or propose commencing the coordinated experiment during the current season should do so and should forward the results to the coordinator as hitherto; and that, after the current season, the subject should be periodically reviewed as data accumulate and should be included in the Working Party's agenda from time to time for this purpose.

5) All countries working on the biological control of rice pests should continue to do so and that all available information should be sent to F.A.O. in Rome for preparing a consolidated report for consideration and necessary action by the Working Party at the next meeting.

6) At the proposed station for research on biological control of pests to be established in India, early attention should be given to the parasitical control of rice stem borers in view of the serious losses of this crop due to them.

7) Member countries should, wherever facilities exist, intensify their work on breeding new varieties resistant to blast disease; that genetic stocks maintained at the four centers, with the exception of Indonesia where such disease does not occur, should be tested for susceptibility to it in order to isolate resistant varieties; that the Director of the Central Rice Research Institute, Cuttack, India, prepare for distribution a list of all available resistant varieties; and that in view of the possible physiological specialization of the pathogen, all known resistant varieties should be tested in all countries where such disease occurs, with full information of the conditions under which they are grown in the country of origin to be made available.

8) F.A.O. should suggest to member countries the inclusion of mycologists and entomologists in their delegations to the next meeting of the Working Party for a fuller discussion of the losses of rice due to pests and diseases in the light of information available from Japan, India, Malaya and elsewhere; and that the possibility of initiating a co-operative action should then be considered.

9) In view of handicaps experienced by rice breeders for lack of sufficient knowledge of the genetics of rice, member countries should make provisions for an intensive study on rice genetics by providing facilities and training personnel for the purpose; and that, as a step of encouragement, F.A.O. should organize a small committee to examine the present position of linkage studies in rice, to resolve difficulties

of nomenclature, and to submit a report at the next meeting of the Working Party.

10) In view of the importance of quality assessment in rice selection and the growing interest in this subject, F.A.O. should collect information on the milling and cooking quality of rice and techniques used for presentation at the next meeting of the Working Party.

Working Party on Fertilizers

This Working Party recommended that:

1) In view of the undoubted value to participants of the Second International Training Course on Soil Fertility in Relation to Rice Growing, which was held at Himayatsagar Agricultural Experiment Station, Hyderabad, India, in 1955, consideration should be given to repeating this course as soon as convenient.

2) Copies of the lectures delivered at all the Training Centers on Soil Fertility should be reproduced and circulated to all member countries.

3) Since it is the general opinion that rotation of padi with dry land crops will benefit rice production, member countries should continue or even expand investigations on the effect of such systems of agriculture on the growth and yield of rice. It was recognised, however, that one-year rotations continue to be the system best adapted to tropical countries. It was further recommended that great care should be taken in the choice of layout for such long term trials and that agronomists should consult statisticians early in the planning stage to ensure that such trials would yield the maximum amount of information.

4) In view of the value of graphic presentation of data from fertilizer trials to member countries, this method should be adopted in future reports. It was further recommended that, where possible, the following data should be recorded for each response curve:

(a) An estimate of the area to which the data are applicable.

(b) Whether the crop is seeded or transplanted.

(c) Whether the area is rainfed or irrigated.

(d) As full a description as possible of the soil type or soil series to which the response data refer.

(e) Time and method of application of fertilizers.

(f) Any other relevant information.

5) Member countries should endeavour to carry out the analysis of soil samples collected from the sites of fertilizer experiments and to give a full description of the soil type or profile in order to study the correlation of yields with data obtained from such soil studies. In making this recommendation the Working Party recognises that each member country will continue to use its proven methods of soil analysis.

6) Member countries should give top priority to the study of soil fertility factors in order to make the best use of the high yielding varieties of padi which are at present available. In this connection, it is emphasized that the higher the yield of padi varieties in any particular area, the greater is the need for maintenance and improvement of soil fertility.

7) In view of the proven value of conducting simple fertilizer experiments on cultivators' fields, member countries should consider the adoption of this method of combining sound agronomic research with effective extension. It was further recommended that the principle of random sampling in the selection of sites should be followed.

8) The attention of member countries be drawn to the value of foliar anslysis in the study of rice nutrition.

9) The attention of member countries be drawn to the possibility of obtaining technical assistance from F.A.O. in the fields of soils and statistics.

10) One particular field of rice agronomy should be selected for comprehensive review and discussion at each meeting of the Working Party namely:

(i) in 1956, a summary of the results from manurial trials, with all forms of NPK, which have been carried out during the last ten years, and

(ii) in 1957, a study of the effect of nursery manuring on the growth and yield of rice.

Recommendations made at the Joint Sessions of the two Working Parties

At the joint sessions of the Working Parties on Fertilizers and on Rice Breeding it was recommended that:

1) When the *ad hoc* Working Party on rice soil-water-plant relationships has presented its report at the 1956 meeting of the International Rice Commission, consideration should be given to the initiation of research by member countries on a co-operative basis.

2) Member countries should continue their investigations on physiological diseases of rice on a co-operative basis.

3) Member countries should continue co-operative investigations on the interaction of fertilizer response with varieties. It was further recommended that, where such an interaction has already been clearly demonstrated, consideration should be given to separating the effects of the different nutrient elements by suitable investigations and that the time of application of each of these nutrients should be studied in relation to their effect on this interaction. At a later stage in these investigations, a study might be made of the gradient of the response curves of different varieties, as suggested by the co-ordinator.

CHANGES IN RICE VARIETIES IN THE UNITED STATES FROM 1931 TO 1955

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There was a marked change in rice varieties grown in the United States between 1931 and 1955. Acreage reports on rice varieties in the United States are compiled annually.[2] Practically all varieties grown since 1951 were developed and released by the United States Department of Agriculture in co-operation with four state agricultural experiment stations. These improved varieties were grown on 99.5 percent of the rice acreage in 1955. In 1931 the varieties developed by these agencies were grown on only about 18 percent of the acreage. The varieties grown in 1931 that are still in production are short-grain types largely grown in California.

By 5-year average percentage of the total United States acreage represented by each variety is given in table 1.

The shift to new varieties resulted from (1) a desire to avoid losses from diseases, (2) change in harvesting methods, (3) higher yielding capacity, (4) improved milling quality of the new varieties, and (5) consumer preference for certain types which caused a varietal price differential.

The medium-grain varieties Blue Rose and Early Prolific and the long-grain varieties Lady Wright and Edith were the leading varieties until after 1940. These varieties are all very susceptible to white tip and to the leaf spot diseases caused by *Helminthosporium oryzae* and *Cercospora oryzae*. The prevalence of these susceptible varieties favoured the spread of these diseases so that they were causing serious reductions in yield by 1940. Disease losses were partly responsible for the shift to resistant varieties such as the long-grain varieties Fortuna, Rexoro and Nira, which had been released a few years earlier, and to Zenith, a medium-grain variety which was released in 1937. About 1943 the combine harvester came into use in the Southern rice area. When the rice is harvested with the combine, it is necessary to dry the grain immediately so it can be stored safely. Varieties such as Blue Rose, Early Prolific, Lady Wright and Edith are difficult to harvest with the combine and hard to dry. This hastened the shift to the newer varieties. Taxas Patna, a long-grain variety similar to Rexoro but about 10 days earlier, was released in 1942. Bluebonnet, a long-grain variety that is somewhat resistant to White Tip and Cercospora leaf spot and well suited to combine harvesting was released in 1944. This variety is also very productive in the Southern area so that the acreage increased rapidly. The older varieties were soon replaced.

The increased consumer demand for long-grain varieties caused a shift to a larger proportion of this type. It can be seen in table 1 that only 11.8 percent of the total United States acreage was sown to long-

1 Research Agronomist in Charge of Rice Investigations, Field Crops Research Branch, ARS, U.S.D.A.

2 Rice acreage reports compiled and released by the Rice Millers' Association, New Orleans, Louisiana.

grain varieties from 1931 to 1935, but this increased to 48.7 percent by 1951 to 1955.

Other varieties developed in the co-operative rice-breeding project include Century Patna, a long-grain variety; Kamrose, Arkrose, Magnolia, Calady and Calrose, medium-grain varieties; and Cody, a short-grain variety. The acreage of Kamrose and Arkrose is reported under "Roses", and that of Calady and Calrose is reported under "Other medium-grain". The acreage of Cody is included under the short-grain class which, practically speaking, consists of varieties developed in the cooperative project.

The success in breeding new varieties and in their adoption by growers has resulted from (1) the development of varieties better suited to conditions on the farm, (2) experiments and demonstrations that permitted farmers to see comparisons between old and new varieties, and (3) a system for the increase and distribution of pure seed of the new varieties.

Table 1 – Five-year average percentage of each rice variety grown in the United States, 1931 to 1955.

Variety and Source	Percent of United States Acreage				
	1931–35	1936–40	1941–45	1946–50	1951–55
Old Varieties					
Lady Wright	4.0	1.5	1.1	0.2	0
Edith	2.6	1.6	0.6	0.1	0
Blue Rose	54.2	51.5	29.5	4.2	0.5
Early Prolific	19.1	16.2	17.4	3.4	0
Total	79.9	70.8	48.6	7.9	0.5
Improved Varieties					
Fortuna	2.9	2.5	4.7	6.0	0.1
Rexoro[1]	1.9	9.4	17.7	21.6	11.7
Nira	0.4	3.2	2.3	2.8	0.2
Bluebonnet	0	0	0.1	12.6	25.3
Century Patna	0	0	0	0	10.1
Other Long-grain	0.3	0.1	0.7	3.6	1.1
Zenith	0	[2]	9.6	25.0	28.4
Magnolia	0	0	0	1.8	2.4
Roses	0	0	0.4	2.2	1.7
Other Medium-grain	[2]	0.5	0.3	0.2	0.1
Short-grain	14.6	13.5	15.6	16.3	18.2
Total	20.1	29.2	51.4	92.1	99.5

Texas Patna included with Rexoro.

2 *A small acreage grown during this period.*

SAMPLING AND ANALYSIS OF PADDY SOIL

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In many countries of the world, soil chemical tests are now considered sufficiently reliable to serve as a primary basis for detemination of fertilizer and lime requirement of soils. In many areas, the individual experiment stations or commercial laboratories each developed their own methods of analysis and systems of interpretation adapted to a limited number of soil types and cropping systems within their service area. Consequently, there had been a wide variation in the methods employed, and some contradiction in theories of fertilization programs recommended from soil test data. In recent years, considerable progress has been made toward standardization of procedures for sampling and analysis of soils Laboratories within similar soil regions have co-operated in uniform tests to correlate test results with fertilizer response in greenhouse and field experiments. It is probable that similar methods of sampling and analysis may be employed for rather wide varieties of soil and cropping systems, so long as correlation data is available to provide for adjustments in interpretation of the data as may be necessary for the specific local conditions. It is questionable whether the methods used on unflooded crop soils can be used on paddy fields for determination of rice fertilizer needs.

Method and Time of Sampling

Numerous studies have been made to evaluate procedures for sampling field soils (7, 17).[1] The composite system is most suitable for practical purposes, although there are indications that analyses of numerous individual spot samples may result in greater accuracy of interpretation for recently cleared fields or others of extreme soil variability. Comparison of topsoil and subsoil analyses on individual vs. composite samples from old rotated paddy fields in Arkansas rice areas show a relatively high uniformity within many fields up to 50 acres in area. The loessial and alluvial soil types common to this area were relatively uniform in their natural state. In paddy regions of similarly uniform soil type fields up to 20 and 25 acres in size may be sampled as a unit, the composite representing at least 15 to 20 individual samples. In regions where variability is extreme because of soil type or management practices, smaller units of less than five acres are preferred; the small units should also be represented by a composite of at least 15 to 20 individual samples. It is always desirable to obtain separate samples from spots of abnormally high or low productivity within any field. On fields where the soil variability cannot be adequately judged by experienced observation and where knowledge of past manage-

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1 *Numbers refer to literature cited.*

ment is limited, composite samples may be taken within small areas at numerous locations for separate analysis, to permit a diagrammatic representation of the soil test results on a map of the field and provide for a study of the chemical variation which exists.

In the initial phases of developing a soil testing program for any region, topsoil and subsoil samples should be collected for separated analyses. Results of numerous comparisons indicate rather consistent chemical similarity among subsoils within regions of similar soil type, regardless of differences in cropping, fertilization, or other management practices on the fields included within that soil type. This situation is particularly outstanding in rice soil regions with impermeable hardpans at depths of five to eight inches, if all subsoil is considered to be below the hardpan and unaffected by leaching. On the other hand, topsoil (furrow slice) analyses usually reflect differences in the past management practices, and may show greater chemical variation among fields within the same soil type region than among fields of different soil regions. For purposes of routine evaluation of general fertility requirements, sampling of the topsoil zone should be sufficient in conjunction with limited consideration of the general subsoil characteristics. It is obvious that rice obtains some of the nutrients from lower depths, but the quantity may be considered small in proportion to the nutrients absorbed from the top zones during early stages of growth (13, 16). There is a need for further studies of rooting characteristics to qualify desirable sampling depth, and it must be realised that such desirable sampling depths may differ among fields according to soil physical properties, cropping systems, and possibly irrigation practices.

The time of sampling paddy fields can be of greater significance than depth of sampling, insofar as it more directly concerns the effects of submergence upon the status of extractable elements. Many workers have substantiated the concept of at least two narrow vertical zones of extreme chemical variation within the topsoil under submerged conditions, resulting primarily from differences in oxidation-reduction relationships within the various depth zones (20, 22). The quantity and nature of salts present in the flood water can also result in wide but less abrupt chemical variation among narrow zones in the topsoil. Soil samples representing a slice or bore through a submerged topsoil indicate a weighted average of all zones, and may thus mask significant differences between zones. It can be assumed that such an average analysis is valid only if the rice roots are absorbing nutrients from all zones simultaneously over a considerable period of growth. The continual movement of root absorption loci and dynamic nature of soil chemical conditions complicate this assumption, particularly under submerged conditions. From the practical standpoint, fields which are flooded or otherwise very wet cannot be easily sampled because of inconvenience and difficulty in properly mixing the individual samples for a composite. In consideration of the factors above, it seems de-

sirable to collect samples from paddy fields during periods when the soil is not flooded, and specifically when the soil is at a moisture content near the ideal for cultivation without puddling or cracking. Fields cannot be sampled immediately following fertilizer, lime, or other manurial treatments and preferably no sooner than several months or at least one crop following such treatments. With respect to the time of year for sampling, the seasonal variation of most major fertility factors can be predicted on the basis of published data available for many climatic regions and adjustments made accordingly in interpreting the results.

After collection in the desirably moist, but not saturated state, the sample must be dried to permit screening out gravel and large pieces of roots or other organic wastes above 2 mm size. For certain types of analyses, or if small sample aliquots are to be used, screening through 1 mm sieve may be more desirable to reduce sampling errors. Gradual air-drying is generally preferred to oven-drying, to avoid unnatural release or fixation of available nutrients depending upon the nature of clay minerals present. Analysis of wet samples directly from the field, without drying, presents the possibility of considerable errors and may not be readily adaptable to rapid, routine testing. The dried, screened sample may be either analysed directly, or incubated at a constant humidity and temperature for a given period before analysis, or incubated under various degrees of submergence for given periods before analysis in such condition (1). The choice of procedures must be determined by the extent of knowlege of flooding effects upon the nutrients in the soil in question.

Chemical Effects of Flooding

Numerous workers have reported on changes in soil fertility factors resulting from alternate wetting and drying or submergence for various time intervals following drying (2, 3, 8, 12, 14, 19). Several outstanding studies have been made concerning chemical phases of submerged soils in general, and paddy soils in particular (18, 20, 23). In most soils there is a tendency for the total amount of exchangeable cations, including hydrogen, to increase and the active hydrogen ion concentration to decrease (pH increase) in the initial stages after flooding. The lack of oxygen and reducing action of anaerobic organic matter decomposition result in an increase in exchangeable and soluble iron, maganese and aluminum, as well as ammonium ions in the major portion of the furrow slice beneath the shallow oxidized layer on the surface. The available[1] phosphorous increases as a result of reduction and solution of iron and possibly aluminum phosphates and release of organic phosphorous, providing that the calcium concentration of the water is not high enough to hold the phosphorous in unavailable forms. Sulfides and other reduction products may increase depending upon the amounts of iron and manganese initially present. The concentrations of soluble sulfide, ferrous, manganous and aluminum ions may increase to toxic pro-

1 Available refers to ions in solution, soluble or readily exchangeable forms.

portions if the initial concentration of these elements is relatively high before flooding and if the reduction action is prolonged sufficiently (9, 10, 11). Toxic concentrations of one or more elements are often concommitant with deficiencies of others; high concentrations of ferrous ion could conceivably interfere with absorption of calcium, potassium and magnesium. The presence of adequate organic matter, regardless of its reduction tendencies, may help to buffer toxic amounts of ferrous or other reduced ions in certain soils (18). Soils which may be initially deficient in iron, phosphorous, manganese or even nitrogen and potash under dry cropping conditions may release adequate amounts of these elements for normal rice growth the first season under flooding; however, the ultimate effect of repeated submergence is to hasten the depletion of natural soil fertility unless fresh supplies of organic matter and fertilizer nutrients are added (4).

Methods of Analysis

At present, methods of analysis are probably the least significant source of error in the evaluation of fertility requirements of paddy soils. Most of the buffered salt solutions currently employed for extraction of exchangeable cations give reproducible results which have indicated satisfactory correlation with rice response to fertilizers and lime in the limited comparisons available (4, 5, 6, 15). The use of neutral normal ammonium acetate permits rapid determination of potassium, calcium, sodium and magnesium with a flame spectrophotometer; other active ions including ferrous and ferric iron, manganese, aluminum, sulfate and phosphate may be rapidly determined by colorimetric or turbidimetric procedures on the same extract. Total nitrogen, measured directly by Kjehdahl or approximated from the organic carbon content, serves as a satisfactory approximation of the nitrogen requirement of paddy soils if interpreted in consideration of drainage conditions, pH, and other soil factors affecting nitrogen release and utilization. More specific estimates of nitrogen requirement may be gained by incubation and subsequent determination of nitrate and/or ammonium released, but interpretation of such results presents problems similar to those with total nitrogen. The numerous phosphorous extracting solutions all have advantages for specific forms of soil phosphorous on specific soil types. Extensive uniform phosphorous correlation tests with dryland crops in the United States have indicated reliable results with the 0.1 N hydrochloric acid–0.03 N ammonium fluoride extraction on wide varieties of acid and neutral soils; sodium bicarbonate extractions appear to be more suitable for alkaline soils (21). The dichromate-sulfuric acid wet oxidation method for carbon is readily adapted to rapid analyses of large numbers of samples, and provides a useful approximation of readily decomposable organic matter. A measure of organic matter content is essential as an aid in estimation of the extent of reduction under submerged conditions.

Interpretation of Results - Conclusions

In consideration of the appreciable errors which will always be involved in

collection and interpretation of paddy samples, there is little justification in developing extreme precision in methods of analysis or subjecting numerous routine samples to incubation under submerged conditions before analysis. If sufficient basic information can be obtained concerning the primary soil factors which determine the extent of chemical changes known to exist under submergence, then results of air-dried soil analyses may be interpreted with reasonable accuracy in determining profitable fertilizer needs. At the present time, soil samples from Arkansas rice farms are immediately processed after air-drying, including tests for readily oxidized organic matter, pH, exchangeable hydrogen, potassium, calcium, magnesium and available phosphorous extracted with 0.1 N HCL–0.03 N NH_4F. The nitrogen fertilizer requirement, if any, is determined from consideration of the organic matter content, pH, soil type and past cropping history; increments of 0, 40, or 80 lbs. N may be recommended according to the classification of low, medium or high nitrogen supplying power of the soil. The phosphorous supplying ability of the soil may be considered either adequate or low, and is estimated from consideration of the extracted P_2O_5, organic matter content, and pH; increments of 0 or 50 lbs. P_2O_5 are recommended if the classification is adequate or low respectively. Limited correlation tests with field experiments at this station have indicated total organic matter content and pH to be among the primary factors determining the amount of P_2O_5 released under submergence. Potash supplying power of the soil is estimated from the exchangeable potassium in consideration of organic matter, percent potassium saturation of the exchange capacity, percentage silt and clay, and nature of clay mineral; increments of 0, 40 or 80 lbs. K_2O may be recommended if the classification is high, medium or low respectively. Special treatments including organic matter, iron and other trace minerals, or acid forming materials may be recommended for unusual conditions or highly alkaline or otherwise abnormal soils, as indicated from the soil pH and past performance of rice crops on the field. Nearly all rice in this area is rotated with dry land crops such as soybeans, oats, lespedeza or pasture, the rice being planted only once every three years, or two every five years. Under such cropping systems the soil samples are often collected during one of the dry crop years and tested primarily for fertilizer requirements of the dry crop. If soil chemical conditions are properly balanced for good production of preceding dry crops, there is seldom benefit from direct fertilization of rice with elements other than nitrogen. Rice is an efficient feeder for residual fertilizer, due to the physiological nature of the plant and the action of irrigation water in promoting organic matter decomposition and nutrient release.

There is a definite need for (a) more fundamental information concerning changes in availability of nutrients after flooding wide varieties of soil types; (b) more complete knowledge concerning the soil and water quality factors which govern the extent of these changes under flooding; and (c) accumulation of complete soil test data

on submerged and dry samples from experimental sites of known fertilizer response.

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RICE ROTATIONS IN NEW SOUTH WALES

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Introduction

A brief review of the history of the rice industry in New South Wales appears necessary to understand the developments in crop sequences which have occurred.

Many attempts were made from 1891 onwards to establish rice in New South Wales with consistent lack of success, due mainly to unsuitable varieties, but in 1922 seed of three varieties, Caloro, Colusa and Wataribune, was obtained from California. Experiment plots using these three varieties, grown under flooded conditions on the Murrumbidgee Irrigation Areas (lat. 35°S), proved to be the foundation of commercial rice production. In 1924–25 157 acres produced 222 tons of paddy, an average yield of 1.41 tons per acre. The present acreage (1954–55) is 38,750, expected to average 2.5 tons per acre. A steady rise in average yields per acre has occurred, which is attributed to three main factors:

1. The development, continuous selection and provision of pure seed supplies.
2. The increasingly widespread adoption of sound crop rotation practices by rice growers.
3. Better water control as a result of the adoption of contour banks to replace the former approximately rectangular bay system. More efficient land surface grading has also resulted.

The farms which are now growing rice have 200 to 600 acres of irrigable land. Because the total water supply is limited and many other crops, particularly tree fruits, require a share of it, also because rice has a

much higher water requirement than other crops per unit area, the supply available for rice is allocated annually among intending rice growers. This usually amounts to an area of 80 acres maximum per grower, based on the usual consumption of 5 to 7 feet of water per acre. Before the advent of rice these farms were growing mainly wheat and some oats for both grain and hay, feeding off the stubble and the volunteer native pasture growth with sheep. Fortunately, one of the volunteer plants was ***Medicago denticulata;*** this and the customary use of superphosphate on the cereal crops helped to maintain fertility.

On the advent of rice as a crop it was first fitted into the above rotation, occupying a different part of the individual farm each year.

The rotation then became:

Rice + 2 cwt. sulphate of ammonia per acre, stubble and volunteer pasture grazed off with sheep:

Wheat + ½ cwt. superphosphate per acre, sheep grazed on stubble and volunteer growth, then short cultivated fallow.

(Wheat repeated several times, with oats sometimes substituted before returning to rice. Leguminous crops, grazed off or not, were also tried.)

About 1948 the practice of sowing pasture mixtures, demonstrated by the Department of Agriculture's Experiment Farm, commenced to be adopted. The best proved to be, and still is, a mixture of Subterranean Clover ***(Trifolium subterraneum)*** and Wimmera ryegrass ***(Lolium rigidum)***. Both these species are annual in habit but seed readily under good management and regenerate the following season, behaving in this respect like a winter-growing permanent pasture. This mixture provides abundance of feed in autumn, winter and early spring. The increasing adoption of this pasture phase was assisted by the increasing market value of sheep, both for wool and particularly for fat lambs, at the expense of wheat which faced a less profitable market, and this position has persisted since.

After two, three or more years of pasture, it was also found that the previously universal practice of applying 2 cwt. of sulphate of ammonia to the rice crop at sowing was not only unnecessary but dangerous. Apparently the accumulation of nitrogen in the soil due to the clover was so great that not only was there ample for the rice crop without addition of chemical fertilizers, but sometimes even too much. When this was anticipated it became the practice to grow an intervening crop of grazing oats after the pasture and before the rice. The pasture is top-dressed annually with at least 1 cwt. superphosphate per acre. The use of sulphate of ammonia has practically ceased except for rice sown on virgin land.

The rotation most widely used now is:

Rice – no fertilizers, following pasture:

Two or more years pasture – sown with 1 cwt. superphosphate per acre into the rice crop either at harvest, from the harvesting machine or into the stubble

immediately after harvest by a mechanical broadcaster, or by airplane;

Grazing Oats — varieties like Algerian are used which can be grazed off up to 4 times and can then be cut for hay or allowed to ripen for grain.

If the sowing on rice stubble fails or is not made, due to dry weather (irrigation water is cut off at the end of each rice season to permit repairs to irrigation canal etc.) the rice stubble is grazed, ploughed in January, fallowed, with cultivation as necessary to control weeds, worked to a fine seed-bed and pasture seeds are sown with the drill in autumn.

Subterranean clover is now often regenerating spontaneously after rice following several years of pasture because of its habit of forming a certain proportion of hard-coated seeds which survive inundation of the rice.

Rotation Experiments

Early investigations showed that ploughing under of field peas (*Pisum sativum*) and tick beans (*Vicia faba* var. *minor*) as green manure was uneconomic; it is much better to graze the crop off and plough in the residue.

Four consecutive years of replicated experiments to compare the effect on rice yields of various grazed crops with sulphate of ammonia averaged as follows:—

Treatment	Average rice yield per cent (4 years)
Fallow + 2 cwt. sulphate of ammonia	147
Tick beans	152
Field peas	146
Oats and field peas	125
Oats	108
Fallow	100

However, a clover-grass pasture soon demonstrated its clear superiority over any available crop as a means of maintaining and increasing fertility.

While these and other simple pilot experiments in rotation were being conducted by the Department of Agriculture during the early years of rice led to the present recommendations, it became obvious that a detailed and necessarily somewhat complex experiment should be designed to compare various systems of rotation. Much planning finally resulted in a project which had to be abandoned due to diversion of staff to other duties during the war and was further delayed after the war for the same reason until 1950. In the meantime further thought was given to the rotation experiment which was eventually sown in that year, to compare five rotations, each replicated five times, and expected to run a 25-year course.

The objectives laid down were:

1. To determine the economics of different rotations or practical systems of land use in the rice-growing areas;

2. To study the relationship between yields of crops and pastures and soil fertility in these rotations;
3. To conduct hydrologic and chemical studies.

The rotations, sown in randomised 5 – replicated half acre plots, were:

Rotation	Years 1	2	3	4	5
1.	R	N	R	N	W GO
2.	R	N	W	W	W GO
3.	R	PS	P	W	W GO
4.	R	PS	P	P	W GO
5.	R	PS	P	P	P

Key: R = Rice.
N = Natural regeneration of native pastures after rice.
W = Wheat for grain.
GO = Grazing oats.
PS = Wimmera ryegrass and subterranean clover sown in rice stubble.
P = Wimmera ryegrass and sub. clover pasture (self sown, i.e. natural regeneration).

The W. GO term may seem odd, but it represents a common practice; after harvesting of the wheat crop in December, the land is ploughed in early February and oats are sown in late February of the sixth year. The oats are grazed heavily, ploughed under the mid August and the land prepared for rice sowing in October, recommencing the cycle

The sowing and fertilizer rates used, per acre, are:

Rice – 120 lb., with 2 cwts. sulphate of ammonia in rotations 1, 2, and 3 only.
Wheat – 60 lb., with 84 lb. super.
Wimmera ryegrass and Subterranean clover – 3 lb. of each, with 112 lb. super at sowing, topdressed at the same rate with super each year pasture remains.

No attempt has been made to give each rotation exactly the same amounts of fertilizer. The experiment is essentially a system of cropping comparison and it was considered undesirable to vary recommended practices.

Each plot is individually accessible, independently watered and drained.

The following items are being measured: crop yields, water use, water table, soil moisture.

Chemical investigations include: total nitrogen and organic matter of soils; protein content of rice and wheat grain.

Stocking data are kept as sheep grazing days.

This rotation experiment has just completed its first 5-year cycle; results to date are being collated, statistically analysed and chemical analyses completed.

Full results for the period are not yet available, but the following trends are apparent:

1. Increased yields of individual crops of both rice and wheat from the less arable (containing more pasture) rotations, but progressively less total grain yields, counterbalanced by a much greater amount of grazing.

2. Average protein content of wheat samples is higher in the case of those from rotations containing more pasture.

Rotation	Average wheat protein
1.	8.0 percent
2.	8.2
3.	8.4
4.	9.3
5. (No wheat)	

These trends fovour the wider adoption of pastures in commercial rotations which has developed in very recent years as a result of the increasing value of meat and wool in comparison with cereals.

3. Measured water usage is higher than normal for all rice bays due almost certainly to their small size and the relatively greater proportion of bank to volume of water.

RICE BREEDING IN SURINAM

The two principal aims of rice variety improvement in Surinam are resistance to lodging and good quality of the grain. As the productivity of the local varieties (of which Skrivimankoti is by far the most popular) is high, the selection programme is not primarily concerned with obtaining a higher yield. Stiff-strawed varieties however are becoming more and more necessary as mechanised cultivation is making rapid progress, and the grain quality of Skrivimankoti-grain badly needs improvement.

The variety improvement programme is principally based on selection in hybrid populations. Improvement of indigenous varieties by pure line selection did not give any results worth mentioning as none of the lines derived from them showed enough resistance to lodging. Nor was the introductoin of foreign varieties very successful as these were less productive than Skrivimankoti.

The result obtained from hybridization however are very satisfactory. The hybrid material was obtained from crosses made during the war between Skrivimankoti and some varieties from the U.S.A. (Rexora, Blue Bonnet and others). From this material 3 strains were derived in 1953 and later on 2 of these were discarded. The remaining strain, VD 5096, is not a pure line as it is still segregating, but lines which have been derived from it are approaching homozygosity.

In 1955 seed of VD 5096 and of one of the newer lines, VD 5096/25, was distributed for the first time on a large scale to farmers under the name of DIMA. The principal qualities of DIMA are high yield, stiff and short straw, high quality of the grain (1,000 grain weight = 29 $\frac{1}{2}$ gr.), and little photoperiodic sensitivity. This variety favours a rich heavy soil and is not adapted to sandy areas.

Beside DIMA some other new lines have been selected which seem to be very promising. It is even expected that they will better the results of DIMA. They are:

VD 5096/69	VD 52470
VD 5096/73	SML 77/4/4/5
VD 52394	SML 77/5/10/2.

Mention must also be made of some crosses which have been made recently between the VD lines and a variety, "Ghent," introduced from Madagascar and well known for its very long grain. Although the material obtained from Ghent seems to be promising, it is still too early to draw any definite conclusions.

FOLIAR SYMPTOMS OF DEFICIENCIES OF THE MAJOR ELEMENTS IN RICE

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Introduction

The ability to identify mineral deficiencies in plants in the field is of considerable assistance in maintaining healthy plants and improving crop yields. Deficiencies are usually recognised by their specific effects upon leaf shape and colour and, in grain crops, upon stem and seed colour. Foliar symptoms resulting from deficiencies of the major nutrient elements may be known in several countries. However, a search through the literature revealed no descriptions of major (or minor) nutrient deficiency symptoms of rice and there is, therefore, no guide at hand to assist in defining these symptoms in Malaya.

The causes of many of the leaf discolourations that occur in the field are unknown. It would be of considerable value to be able to differentiate between the leaf symptoms resulting from a nutrient

deficiency and those due to the other physiological diseases.

In order to define the foliar symptoms of major nutrient deficiencies, e.g. N, P, K, Ca, and Mg, on a local variety, a sand culture experiment was set up in 1954.

Experimental Details

The concentrations of the nutrients were based on a paper by Espiro and Esteoko (1) and the rice variety used was Siam 29. The treatment consisted of the reduction of nitrogen to one-half and to one-tenth of the concentration of the control; phosphorus, potassium, calcium and magnesium were used at one-third the concentration of the control or were completely absent.

Leaf Symptoms

Nitrogen Deficiency. The first symptom was a generally light green plant, with the older leaves lighter green than the younger ones. The tips of the older leaves then started to die back, first turning reddish-brown and then a light yellow. Necrosis progressed down the leaf edges first, but spread until all the leaf tissue was eventually involved. There was no sign of interveinal chlorosis in this process.

The main diagnostic symptoms at this stage were apparent in the necrotic portions of the leaves, which were light yellow, papery to the touch, and, with few exceptions, unrolled.

Plants suffering from severe nitrogen deficiency were, also, very stunted and had narrow leaves.

Phosphorus Deficiency. The older leaves first turned light green at the tip and then yellow spots appeared in the interveinal tissue of the top one to two inches of the leaves. A small amount of reddening sometimes appeared in the tip area, but was usually confined to the very tip and leaf edges, preceding necrosis. Necrosis began at the tip and proceeded down the leaf edges, normally only two to three inches ahead of general necrosis. Occasionally it proceeded rapidly down the leaf edges for three-fourths the length of the leaf. The dead tissue was always light brown in colour. Necrosis did not involve the mid-rib, with the exception of a small terminal portion, until the whole leaf died.

The necrotic areas were rolled inward parallel with the mid-rib of the leaf; in severe deficiency the green leaf took on a V-shape with the mid-rib at the bottom of the V. As the leaf became necrotic it curled as in mild deficiency.

Plants suffering from severe phosphorus deficiency, in addition to exhibiting the symptoms just described, were stunted though not to the same extent as those short of nitrogen, and had very narrow leaves.

Potassium Deficiency. In practice it was often difficult to distinguish potassium from phosphorus deficiency. At certain stages the colour patterns were almost indentical. In mild potassium deficiency the tips of the older leaves turned yellow and then the colour extended down the leaf edges for one to two inches. Necrosis followed

at the tips and later progressed down the leaf edges. From the leaf margin to the mid-rib and sequence of colours was observed. The peripheral light brown necrotic tissue bordered a thin line of reddish-orange, on the inside of which was an area of chlorotic tissue one-eighth of an inch or less in width. The marginal yellow band expanded into a wide zone near the dead tip leaving only a green mid-rib. Often the mid-rib itself turned yellow in the transition zone between living and dead tissue. The yellow zone seldom showed yellow spots, as in phosphorus deficiency, and there was a sharper distinction between the yellow and light green zones than was observed on leaves deficient in phosphorus.

The yellow colour, and eventually the brown necrosis, extended rapidly down the leaf edges, often nearly to the base of the lamina, while most of the leaf was still green. The mid rib, except near the leaf tip, was not affected until the leaf died (as in phosphorus deficiency). The dead tissue rolled in toward the mid-rib, but did not make the leaf "V" shaped as in phosphorus deficiency.

Plants suffering from severe deficiency, in addition to showing the symptoms just described, often displayed a visual symptom that was specific for potassium. There was a brown colour superimposed on the chlorophyll of the leaf under the epidermis. This gave the leaf an olive green colour. The colour appeared first at the leaf tips and covered the whole lamina except the mid-rib. The leaf gradually became darker in colour until it suddenly collapsed at the base of the lamina and died. The dead leaf was very dark brown but still retained on olive green hue that could be easily recognised. This colour could be detected in quite an early stage if the affected leaf was held up to strong direct light.

Plants suffering from severe potassium deficiency were often dark green (before turning olive green) and were not stunted to the same extent as those lacking phosphorus or nitrogen.

Calcium Deficiency. The mild symptoms were almost identical with those of potassium deficiency except that not so many leaves were affected. Plants were similar in size and only the oldest leaves were affected. Some interveinal clearing appeared on the older leaves of nearly mature plants and the newly formed leaves were light green in colour and translucent with prominent veins.

In the severe calcium deficiency the leaves lodged early by collapsing at the lamina base leaving only two or three leaves upright at any one time. The plants were spindly and weakly rooted.

A leaf symptom of severe calcium deficiency was marked interveinal chlorosis. The interveinal tissue first became light green and then yellow. The interveinal strips of yellow were prominent and extended to the base of the leaf. Later the leaf tips became necrotic but did not roll. The dead tissue was a reddish-brown colour and included areas of mottled green where the chlorophyll had not completely disappeared before death occurred.

Necrosis commenced by the appearance of small brown spots at the leaf tip. The border zone between living and dead tissue was, therefore, mottled green and brown. As the brown spots increased in size and number they coalesced and the whole area became necrotic. The mid-rib died along with the lamina of the leaf. However, the live portion of the mid-rib was usually dark green.

The appearance of a necrotic spot was first evidenced by a brown colour under the epidermis of the leaf; as necrosis progressed the spot became reddish-brown and the epidermal cells were then affected.

Magnesium Deficiency. The first symptoms were very similar to calcium or potassium deficiency; yellowing leaf tips which later become necrotic. However, these plants soon displayed interveinal chlorosis which was very pronounced and the older leaves lodged fairly readily. The mid-rib of these leaves were usually not so prominent as those showing calcium deficiency. Also, the interveinal chlorosis tended to look more white or light green than yellow and the leaves themselves were light green. The lower half of the older leaves and all of the young leaves had a clear translucent appearance.

The complete absence of Mg resulted in the most unhealthy plants of all those grown. Leaf collapse was very severe. Usually only one leaf was upright and never more than three leaves were alive at one time. The plants never attained a height of over 8 inches. Each leaf as it unfolded would start to roll, parallel with the mid-rib, and shortly after it was completely unfolded it was tightly rolled for its full length and usually lodged. The leaves were narrow and had interveinal chlorosis as already described. After lodging, the leaves shrivelled and died back from the tip leaving a mat of dead leaves around the base of the plant. The dead tissue was medium to dark brown in colour. At the later stages the leaf sheaths on the main stem turned black.

Leaf Analyses

When the grain was mature the plants still alive were harvested and their leaves were analysed (see Table 1).

When the nitrogen was reduced in the nutrient solution to one-half the control (b) the leaf content of all the other elements was increased.

The nitrogen was only slightly decreased but this may have been the result of an antagonistic effect of the calcium at the higher concentration. When calcium was reduced in the solution to one-third the control (f) the calcium in the leaves was reduced and the nitrogen level was the highest for the whole experiment

Table 1 indicates that rice plants are very susceptible to changes in the available phosphate level. When phosphorus was reduced in the solution (c) all five elements were reduced in the leaves and phosphorus

most of all. The reduction of magnesium in the solution (e) greatly decreased the content of potassium in the leaves. On the other hand when potassium was reduced to one-third in the solution (d) the potassium in the leaves was slightly lowered. When no potassium was supplied (g) the leaf potassium was considerably reduced.

Table I

Results of Leaf Analyses

Treatment	Ash	N	F_2O_5	K_2O	Ca O	Mg O
(a) Control	8.68	1.15	1.93	2.83	0.70	0.18
(b) 1/2 N.	11.20	0.85	3.15	3.74	0.96	0.36
(c) 1/3 P.	3.76	1.09	0.30	1.20	0.35	0.10
(d) 1/3 K.	6.70	1.55	1.81	2.18	0.47	0.21
(e) 1/3 Mg.	5.22	1.24	1.14	0.60	0,69	0.14
(f) 1/3 Ca.	6.74	2.84	1.46	2.44	0.44	0.18
(g) – K.	6.57	2.27	1.84	0.43	0.94	0.17
(h) – Mg.	14.17	2.79	3.47	5.32	0.11	0.62

Figures are gm. per 100 gm. of leaf dry weight.

Discussion

The symptoms described here are based on one experiment only, but those described for nitrogen, phosporus and potassium are probably reliable for the variety used. Although one-third potassium in the solution (d) reduced the calcium content (sea Table 1), the plants receiving no potassium (g) displayed both symptoms described and increased the calcium content. Further work should be done to clarify the symptoms of calcium and magnesium deficiency.

An experiment is now underway which, it is hoped, will provide this information and, in addition, an attempt is being made to demonstrate deficiency symptoms of iron.

There has been some indication that symptoms may vary on different varieties, so three different varieties, Pebifun, Radin Siak 34 and Serendah Kuning, are being tried.

If this experiment is successful, coloured photographs will be made of the deficiency symptoms in all the various stages and eventually a colour atlas is expected to be produced.

Literature cited:

1. **Espino, R.B. and Estioko, R.P., 1931.** "A Critical Study of the Nutritive Values of Nitrate Nitrogen for Young Rice Plants." *Philippines Agriculturist,* 20: 27-42.

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